STATEMENT OF

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CHIEF OF NAVAL RESEARCH

BEFORE THE

TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES SUBCOMMITTEE

OF THE

HOUSE ARMED SERVICES COMMITTEE

ON

THE FISCAL YEAR 2011 BUDGET REQUEST

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Introduction

It is an honor to appear before you to report on Science and Technology (S&T) efforts within the Department of the Navy and discuss how the President's FY 2011 Budget supports the Navy and Marine Corps. The President's FY 2011 Budget requests $1.96 billion for Naval S&T.

The Naval S&T objective is to support a Navy and Marine Corps capable of prevailing in any threat environment. Throughout the past year, the Office of Naval Research (ONR) continued a direct, hands-on partnership with the Chief of Naval Operations (CNO) and Commandant of the Marine Corps (CMC). We believe that to address critical challenges facing the Navy and Marine Corps, ONR must: 1) focus on S&T areas that provide the biggest future payoff, 2) be innovative in thinking and business processes, and 3) continue improved transition of S&T into acquisition programs.

S&T Strategic Plan

The updated Naval Science and Technology Strategic Plan, approved last year by Navy and Marine Corps leadership, reaffirms alignment of Naval S&T with current Naval missions and future capability needs. It ensures S&T has long-term focus, meets near-term requirements, and makes our course clear to decision makers, S&T partners, customers and performers. The S&T Plan identifies thirteen focus areas where S&T investment will have high payoff supporting Navy and Marine Corp requirements: 1) Power & Energy, 2) Maritime Domain Awareness, 3) Operational Environments, 4) Asymmetric and Irregular Warfare, 5) Information Superiority & Communication, 6) Power Projection, 7) Assure Access and Hold at Risk, 8) Distributed Operations, 9) Naval Warfighter Performance, 10) Survivability and Self-Defense, 11) Platform Mobility, 12) Fleet/Force Sustainment, and 13) Total Ownership Cost.

Executing the Strategy

We execute Basic Research (6.1) thru Advanced Technology Development (6.3) funds by dividing S&T into three primary areas – Discovery and Invention (D&I), Innovative Naval Prototypes (INP), and Future Naval Capabilities (FNC).

Discovery & Invention

Discovery and Invention (D&I) includes basic research (6.1) and early applied research (6.2) in areas with unique requirements or capabilities essential to the Naval mission. D&I develops fundamental knowledge, provides the basis for future Navy/Marine Corps systems, and sustains the Defense Scientist and Engineer workforce.

Approximately 40 percent of S&T investment is in D&I in order to sustain basic and early applied research. We assess impact on Navy/Marine Corps missions, as well as potential for innovative performance, in order to invest resources in the best research areas and projects. This builds the foundation of our S&T portfolio by developing a broad base of scientific knowledge from which INP, FNC, and quick reaction efforts are generated. Approximately 60 percent of

basic research is executed with academic and non-profit performers, and all programs are peer reviewed.

An important element of D&I is the Defense University Research Instrumentation Program (DURIP), which supports university research essential to Naval research. DURIP complements Navy D&I programs by supporting purchase of high cost instrumentation necessary to carry out cutting-edge research. ONR awarded 68 DURIP grants in FY 2007, 92 in FY 2008, 82 in FY 2009, and plans to award 61 grants in FY 2010. Another D&I program, ONR's Basic Research Challenge, stimulates interdisciplinary research in emerging S&T fields.

D&I investments also support development and sustainment of the S&T workforce. Through Independent Laboratory In-house Research (ILIR) and Independent Applied Research (IAR) programs, ONR sponsors critical research, while furthering education of scientists and engineers at our Warfare Centers. Education and research opportunities for undergraduate and graduate students, fellows, future faculty members and researchers are provided through programs, such as the Naval Research Enterprise Internship Program (NREIP), which expose participants to work done at Naval laboratories.

Through the University Research Initiative (URI) and Young Investigators Program (YIP), ONR gains access to researchers with an understanding of, and willingness to investigate high priority topics of interest to the Navy that intersect multiple technical disciplines. In addition, we continue to support Historically Black Colleges and Universities and Minority Institutions (HBCU/MI) with research and education partnerships. Through demonstration, apprentice, award, and graduate programs, we encourage young people to explore S&T careers in academia, Naval labs, and industry. ONR is now the coordination center for all Navy Science, Technology, Engineering and Mathematics (STEM) educational activities.

In addition to external research, ONR supports research at Navy's corporate lab, the Naval Research Laboratory (NRL). This support, known as the NRL base program, develops S&T to meet needs identified in the Naval S&T Strategic Plan, and sustains world class skills and innovation within our in-house laboratory.

Innovative Naval Prototypes

Innovative Naval Prototypes (INP) represent approximately 10 percent of the S&T budget. They focus on high-risk/high-payoff opportunities emerging from the D&I portfolio that can significantly impact Naval capabilities if we can mature the technology. INPs are discontinuous, disruptive, radical departures from established requirements and operational concepts. Approved and overseen by the Naval S&T Corporate Board (Assistant Secretary of the Navy for Research, Development and Acquisition (RD&A), Assistant Commandant of the Marine Corps and Vice Chief of Naval Operations), the goal is to prove concepts and mature technology within 4-8 years, allowing informed decisions about risk reduction and transition into acquisition programs.

We have six current INPs:

The Tactical Satellite (TacSat) INP will be completed in FY 2010. The TacSat challenge was to build microsatellites demonstrating technologies that help close existing Naval warfighting gaps, provide quick and responsive access to space, as well as easy access to the tactical commander. With six payloads completed, most technology transitions to the Operationally Responsive Space program office in New Mexico.

The Electromagnetic Rail Gun (EMRG) INP continues to develop and test a scalable, more powerful gun, using non-explosive rounds with no gun propellant. The EMRG has more than doubled current state of the art muzzle energy. The EMRG program continues to achieve technical objectives while moving toward scheduled completion of Phase I in FY 2011.

The Persistent Littoral Undersea Surveillance (PLUS) INP is developing an autonomous over-the-horizon Anti-Submarine Warfare (ASW) system that removes humans and manned platforms for detection, location, classification and tracking of submarines. The PLUS INP demonstrates the utility of clandestine unmanned undersea vehicles employing ASW sensors with flexible deployment capabilities. We expect PLUS to complete by FY 2012.

The Sea Base Enablers INP selected three Transformation Craft (T-Craft) concepts for tests to characterize relative motion between vessels, evaluate ramp excursions, and quantify force and structural loads. Results were correlated with computer prediction models, and provided to the three design teams for incorporation into their technology development. We are in Phase II of a three phase program, concluding with prototype construction and demonstration in FY 2013.

The Free Electron Laser (FEL) INP will bring laser technology to sea for ship defense against a variety of threats. Consistent with plans for an all-electric ship, the FEL INP will develop a laser tuned to atmosphere-penetrating wavelengths for use in maritime environments. This will allow us to assess the potential of laser-based shipboard defense that includes tracking, discrimination, countermeasures, and scalable direct fire at the speed of light.

The Integrated Topside INP will enable Navy to dominate the electromagnetic spectrum through development of multifunction apertures for all ship classes. We are also developing: 1) open architecture for Radio Frequency (RF) equipment, plus computer hardware and software that will enable industry to contribute to development of affordable new systems and upgrades, and 2) modular systems that enable the same technology to be scalable across all Naval platforms to significantly reduce logistics, training, and maintenance costs.

Future Naval Capabilities (FNCs)

Our Future Naval Capability (FNC) program is the most critical component of our transition strategy. FNC investments align the "requirements-driven, transition-oriented" portion of the S&T portfolio to Naval Capability Gaps identified by the Office of the Chief of Naval Operations (OPNAV) and Marine Corps Combat Development Command (MCCDC). As opposed to high-risk/high-payoff INPs, FNCs are near-term projects included in the part of our budget focused on Acquisition Enablers (approximately 30 percent). The FNC process delivers

mature technologies to acquisition sponsors for timely incorporation into systems that provide new capabilities to the warfighter.

FNCs are based on earlier D&I investments, where technology has matured to the point that it can achieve a Technology Readiness Level (TRL) of 6 or better within 3-5 years. FNC projects are selected annually to address specific capability gap needs, with final prioritization approved by a 3-Star Technology Oversight Group (TOG) representing OPNAV, United States Marine Corps (USMC), U.S. Fleet Forces Command (USFF), Assistant Secretary of the Navy (ASN-RDA) and ONR.

Approved technology products are required to have Technology Transition Agreements that document the commitment of the resource sponsor, acquisition program, and ONR to develop, deliver and integrate products into new or upgraded systems that can be delivered to the Fleet/Force. Every FNC product's progress and status is reviewed annually. Products that no longer have viable transition paths are terminated with residual funding used to solve unexpected problems with existing projects, or start new projects in compliance with Navy priorities.

The measure of FNC success is whether projects meet technology requirements and exit criteria, and whether acquisition sponsors have transition funds in their programs to accept and integrate FNC products. Products with planned transition funds usually transition after risks are mitigated, a definitive plan finalized, and required funding programmed. We have had good success in this effort and expect continued strong performance in 2010.

Increases and Decreases in FNC Funding Levels

It is important to remember: FNC investments focus on the most pressing capability gaps, generating year-to-year changes in funding for associated Program Elements (PEs). As FNC investments mature and develop over 3-5 years, Technology Readiness Levels (TRL) change, moving products from 6.2 to 6.3 PEs. The first year is predominantly 6.2; the final year is predominantly 6.3 – with a mix of 6.2/6.3 in-between. As products deliver and transition to Advanced Component Development and Prototypes (6.4) and Engineering and Manufacturing Development (6.5) funding, new FNC products do not always begin in the same PE as those completed. While resulting changes may appear to be program growth, they actually reflect realignment of funds in response to successful transitions – coupled with reprioritization and new starts based on evolving Naval needs and requirements.

Current S&T Program Highlights

The Naval S&T portfolio includes a range of projects entering the fleet or about to enter in a short time. Following are examples of these efforts outlining the impact they will have on Sailors and Marines, today and in the future.

Manpower, Personnel, Training and Education

In FY 2011, ONR's Capable Manpower FNC is focused on developing innovative, technology-based products to support Navy/Marine Corps Human Capital programs, including manpower,

personnel, training, and human systems design products. These will optimize performance, minimize ownership costs, and ensure systems are built to accommodate characteristics of the user population that will operate, maintain, and support the systems and the warfighters.

In support of *Strategy for Our People 2016*, Capable Manpower will develop a suite of integrated decision support analytical tools to assist managers to forecast and assess the effects of enlisted and officer behavior (recruitment, retention, career decisions, education benefits, etc.) resulting from both current and proposed Navy policies. These tools will help meet the CNO and SECNAV goal of creating a more agile, competency-based workforce that integrates the total force and adopts personnel policies to make Navy competitive in the marketplace.

Another Capable Manpower program goal is to improve availability and reliability of critical information needed by the Commanding Officer and team to make better-informed decisions. To achieve this goal, the program will develop innovative information architecture for future combat control rooms by blending key elements of information processing, team structure, display techniques, and training interventions. Design will be driven by the most critical information requirements of decision makers.

This program will improve operational decision making as a result of transforming command team information flow from data-centric architecture that requires significant cognitive effort to integrate and validate the tactical picture – to decision-centered architecture that frees the command team to allocate more cognitive energy to the complexity of the mission. This architecture will guide information system design, manning, and training for the submarine Ohio Replacement program control room, as well as surface combatant combat information centers.

The program will also develop and demonstrate validated, effective, adaptive training prototype systems to enhance individual and team training. Adaptive systems impart adaptive expertise to the learner – including intuition, creative thinking, problem solving skills – while compressing the learning experience by optimally tailoring experiences, in real-time, to current cognitive and physiological states of the learner.

A unique human systems design approach is developing processes, methods and software specifications to merge the full spectrum of human systems integration into Navy's standards-based, open-architecture, Integrated Product Data Environment for production ship design. The prototype is also focused on the submarine Ohio Replacement program and will demonstrate decreased acquisition and ownership costs while increasing effectiveness of the resulting system.

Marines and Sailors as a System

Marine Corps S&T is coordinated and executed by ONR and the Marine Corps Warfighting Laboratory. These organizations develop and transition technologies to enable the Navy-Marine Corps team to win and survive on battlefields of today and tomorrow. When addressing technologies, the individual Sailor and Marine are treated as a "system". Sailors and Marines are the heart and soul of the Navy and the Marine Corps and together provide the nation a Naval expeditionary force fully prepared for employment across the spectrum of operations. Technologies being pursued today will enable future Naval forces to respond whenever our

country is threatened, to arrive on the scene on short notice anywhere in the world via amphibious ships of the Navy, and to fight and win our nation's battles.

Infantry Immersion Trainer

The Infantry Immersion Trainer (IIT) is a revolutionary training system that prepares Marines and Sailors for deployment to today's battlefield environment. The facility uses virtual reality, physical structures, gaming avatars (virtual characters), pyrotechnics, and live role players – simulating a Southwest Asian village in the midst of combat – to give troops necessary skills to win and survive in battle. Equipped with laser-tag-like weaponry, Marines, Navy Corpsmen, and Army soldiers, walk through realistic dwellings and alleys – including sounds and smells – encountering civilians and enemy combatants. The IIT confronts warfighters with a range of scenarios requiring split-second decisions. High-tech simulation provides a safe, yet realistic, training environment for learning how to prevent fatal errors before being exposed to real threats, with the goal of making the first fire fight no worse than the last simulation.

IIT software allows rapid improvement of training delivery, with simulated scenarios tailored to suit mission or individual needs. Repeatable, scalable scenarios increase skills in less time. Our first IIT facility opened in 2007 at Camp Pendleton; a second is planned for Camp Lejeune in 2010. The IIT incorporates ONR technologies, Defense Advanced Research Projects Agency's (DARPA) RealWorld game-based simulation system, and technologies sponsored by the Army Research Development and Engineering Command's Institute for Creative Technologies at the University of Southern California. ONR continues to improve IIT software, conduct IIT experiments, and is Technical Manager of the Future Immersive Training Environment (FITE) Joint Capabilities Technology Demonstration (JCTD) which will improve the IIT for a demonstration in September 2010.

Marines in Operational Environments

Marines must be able to destroy enemy formations with scalable air-ground-logistics teams in major contingencies, and be equally able to employ superior Irregular Warfare (IW) skills. ONR has taken the lead in balancing traditional and IW capabilities by providing quantifiable technical advantages to warfighters in Afghanistan and Iraq. While IW favors indirect, asymmetric approaches, it may employ the full range of military and other capabilities, in order to erode an adversary's power, influence, and will.

In implementing *Marine Corps Vision and Strategy 2025*, Marine Air-Ground Task Forces (MAGTF) of the future, either from the sea or in sustained operations ashore, must be leaner in equipment. ONR initiatives will help reduce the load of Marines and Sailors through materials and technologies that are much lighter, while providing enhanced protection in combat.

We have initiated a focused technologies approach designed to lighten the load of the individual Marine and lighten the footprint of the Marine Air-Ground Task Force (MAFGTF). Depending on the situation, and including helmet, body armor, weapons, water, ammunition, and batteries, the weight of gear for a Marine on foot-patrol in Afghanistan can average 90 pounds. There is a

delicate balance between weight and protection, and ONR continues to pursue the latest technology to provide Marines with scalable protection based on mission and threat.

Persistent intelligence, surveillance and reconnaissance technology will provide tactically relevant information in all phases of a broad spectrum of operations. It will enhance situational awareness and understanding – enabling real-time decision making that provides proactive, predictive capabilities for Asymmetric and IW, as well as traditional encounters.

The use of unmanned aerial cargo vehicles to rapidly move logistics on a distributed battlefield and complete casualty evacuation, as well as revolutionary robotics to enhance ground logistics delivery, are future capabilities equally applicable to IW and traditional warfare.

ONR has been in front of efforts to improve survivability for the Marine Corps current and future family of tactical vehicles. Efforts to develop optimized fiber composite materials, amenable to advanced high volume fabrication techniques, and active protection systems for vehicles against rocket propelled grenades and missiles help make Marine Corps forces more agile, lethal, mobile and survivable.

Large Scale S&T Demonstrations for Protection of Ground Forces and Systems

As we reported last year, major integrated technology demonstrations are investigating dramatic new capabilities in the Protection of Ground Forces and Systems. The demonstrations are wide ranging, encompassing technologies for pre-detonation of Improvised Explosive Devices (IEDs), personal protection materials and power generation, micro power sources, and augmented reality.

The integrated demonstration program will be a multi-year effort to both investigate technology integration, and spur application of fundamental technologies for force and platform protection. The integration of safer ways to remotely detonate IEDs will require additional power – while technologies to enhance the protection capacity of equipment that mitigates blast effects, blunt trauma, ballistic and directed energy attacks will require new materials and nanomaterials.

Advanced power systems for dismounted Marines will be embedded in the demonstrations. Power systems include advanced batteries, fuel cells, and personal power. Augmented reality will demonstrate fusion of organic and individual borne sensors with existing datasets to provide enhanced decision systems and situational awareness. Resulting successful force protection applications and technologies will see immediate utilization.

An example of technology that already emerged from the integrated technology demonstrations is the Gunslinger Package for Advanced Convoy Security (GunPACs). This program is executing a rapid prototype development strategy coupled with planned system deployment with Marines in Afghanistan this fall. GunPACs provides enhanced situational awareness for ground and logistics elements conducting combat operations. This vehicle mounted technology provides accurate targeting solutions for small units and logistics convoy crews enabling them to effectively and discriminately engage enemy forces with remote weapons while remaining under armor.

Non-Lethal Weapons and Technology Development

The Marine Corps is the nation's expeditionary, combined-arms force. Expeditionary connotes speed, lethality, rapid deployment by air or sea, and efficient, effective operations in an austere environment. This means a task-organized force that is manned and equipped no larger or heavier than necessary to accomplish the mission. Expeditionary means being prepared for decisive action, but also possessing non-lethal capabilities when required.

Non-lethal weapons are devices and munitions explicitly designed and primarily employed to incapacitate targeted personnel or materiel while minimizing fatalities, permanent injury, and undesired damage to property in the target environment. Non-lethal weapons are intended to have reversible effects on personnel and materiel, and include technologies that deny access to individuals, disable vehicles, and entangle vessels. They provide a capability to defend against threats and control crowds, while providing standoff protection for friendly forces. To support the Commandant of the Marine Corps in his role as Executive Agent for the Joint Non-Lethal Weapons Program, a broad spectrum of counter-personnel, counter-materiel, non-lethal weapons are under development at ONR.

Operational Adaptation

As we described last year, Operational Adaptation (OA) is intended to identify, develop, and demonstrate S&T solutions for future conflict. These conflicts, called "hybrid complex warfare" or "hybrid complex operations" may include all elements of conventional, irregular, disruptive, or catastrophic threats. Recognizing that adversaries are adaptive, rather than try to predict the exact threat and counter that prediction, OA provides warfighters with capabilities to develop and sustain a tempo of adaptation and decision-making superior to any adversary. OA anticipates fighting on turf that favors the enemy and is intended to help warfighters orient rapidly, become pro-active earlier, and dominate adversaries with increasing effectiveness.

Unlike large-scale mechanized formations in the industrial age, today's adversaries try to hide by disappearing into complex environments. OA includes the ability to understand "human terrain" – to distinguish between adversarial/non-adversarial populations. Affordable, scalable, persistent surveillance is vital to OA. Our forces have capability gaps in maintaining surveillance over large areas with the persistence and resolution needed to identify threat activity and provide timely indications and warnings. These gaps are caused by limits of current sensor technologies, and by manpower requirements associated with operating individual systems and data interpretation. Several ONR projects are directed towards overcoming these limitations.

Utilization of improved sensors necessitates understanding the resulting data. Where mechanized warfare required understanding the physical characteristics of weapons platforms and their employment, hybrid warfare requires that we understand human phenomena as well. ONR utilizes the social sciences to investigate solutions to problems in human, social, cultural and behavioral arenas. These solutions will help better understand "human terrain" phenomenology, apply that phenomenology in operational contexts, and design or modify technologies that will enable us to make better use of affordable, persistent surveillance products.

ONR is currently conducting an Integrated Technology Demonstration to address operational gaps that preclude adequate warning of non-conventional hostile activities through affordable, autonomous, persistent, pervasive littoral surveillance. Success metrics associated with this demonstration include achieving sufficient advanced warning of hostile intent and actions to enable our forces to respond at the time and place of our choosing – rather than awaiting an enemy attack and then reacting to it.

Improvised Explosive Devices (IEDs)

As we know all too well, IEDs represent a persistent challenge. Continuing our work with the Joint IED Defeat Organization (JIEDDO), ONR funds research efforts aimed at attacking IED networks and devices, and training our forces. Working with other agencies, ONR is investing in prediction efforts involving terrorist activity: bio-forensic profiling to trace place of origin, factory location, support networks, placement, and dynamic analysis of suicide bombing. These projects anticipate threats, and put us in a better position to respond to changing conditions.

Scientists at Columbia, Drexel, University of Miami, and others working in ONR's Automated Image Understanding (AIU) program have developed computational methods and algorithms for recognizing hundreds of object categories, including tracking and analysis of human behavior. The intent is to develop automated identification of people and behavior to highlight potentially threatening situations. AIU is a critical capability for many Department of Defense (DoD) missions including, situational awareness, persistent and adaptive surveillance, and autonomous operations.

Near-term initiatives include the Advanced Technology Development efforts to neutralize IEDs through improved countermeasures as well as locating and directly attacking the device. Long-term S&T includes bio-inspired sensing systems (for example, technologies with the capability to mimic a dog's or an insect's ability to smell) for detection/tracking of explosive components in ports, coastal, and ocean environments. Advances in countering IEDs are compatible with Countermine Warfare in any environment. Efforts are underway to develop novel man/machine interfaces with the ultimate goal of developing unmanned, autonomous systems that separate warfighters from hazardous missions, while providing increased economy of force – an emphasis on autonomy and the development of unmanned systems technologies embedded throughout the S&T portfolio in order to more effectively meet emerging operational requirements.

Expeditionary Energy Requirements

Operations in Afghanistan have forced the Marine Corps to reevaluate energy distribution and use in expeditionary environments. Future challenges will likely require Marines to operate over long distances in austere environments, and we are actively pursuing a wide range of solutions. These include lessening energy consumption and dependence on fossil fuels, while achieving resource self-sufficiency. USMC requirements for energy span the full range of power levels, from watts to kilowatts to megawatts. S&T efforts are focused on energy requirements of individual Marines, small dispersed units, and the tactical vehicle fleet. Investments in battery technologies, advanced power generation from JP-8 fuel, and renewable energy from solar power, combined with technologies that reduce fuel consumption, allow greater mobility and on-

board power for tactical vehicles. These have significantly reduced energy consumption and usage in expeditionary environments.

Mobile, Modular Command and Control for Marines in Afghanistan

An example of ONR's Quick Reaction S&T was our response to a request early in FY 2010. Marines in Afghanistan were seeking a lightweight, interoperable, modular, reconfigurable, rapidly deployable, minimal setup/footprint Command, Control, Communications (C3) package for early entry expeditionary forces at the brigade and battalion level. ONR delivered a first prototype of the Mobile, Modular Command and Control System (M2C2), a C3 package integrating "First In" expeditionary or distributed forces with afloat forces - thereby providing Over-The-Horizon, Satellite Communications (SATCOM) On-The-Move, and a full tactical C3 picture. The initial operational prototype was delivered to Regimental Combat Team-7, which just returned from a demanding 20 day mission to report the M2C2 system operated flawlessly.

Medical Research related to IEDs and Hearing Loss Prevention

ONR continues work with the medical community to better understand the effects of IEDs and develop tools to connect event and medical data. Force Health Protection Advanced Technology Development efforts include modeling human responses to blast, ballistic, and blunt trauma, as well as modeling physical and cognitive effects of blast exposure and conditions arising from traumatic brain injury.

Another area of emphasis is reducing hearing loss and tinnitus experienced by personnel in high noise environments. We are working with medical and acquisition communities exploring multiple approaches to understand the physics of noise, reduce noise, attenuate noise that still exists, monitor and assess exposure, develop advanced personal protective equipment, and develop enhanced warnings and procedures to ensure noise exposure does not become damaging. A suite of technologies developed under the FNC program are now transitioning to the warfighter as part of the acquisition sponsor's Flight Deck Cranial program of record. We are working on treatment, including ground-breaking pharmaceutical interventions for situations where potentially damaging exposure does occur.

Naval Undersea Medical Research

Undersea Medical Research is a National Naval Responsibility. ONR investments: 1) further understanding of health threats to undersea warfighters, 2) develop novel mitigation strategies for decompression sickness, arterial gas embolism, and oxygen toxicity for disabled submariners and divers, and 3) assess other health challenges associated with undersea deployment. Products from our Undersea Medicine Program, such as development of non-recompression strategies for the mitigation of decompression illnesses, the elucidation of biological mechanisms that govern oxygen toxicity, and understanding the epidemiological consequences of undersea deployment will improve efficiency, flexibility, and safety of manned undersea operations.

Ship Survivability and Self Defense

In FY 2011, the Maritime Weapons of Mass Destruction (WMD) Detection program is moving toward more complex demonstrations of Special Nuclear Material detection technologies. These tests will be conducted in representative, Navy unique maritime environments which include over water and under-water applications.

As previously mentioned, the Free Electron Laser (FEL) INP is designed to defend against current and future surface and air threats, anti-ship cruise missiles, swarms of small boats, and other asymmetric threats. The FEL will provide new capabilities to sense, detect, and scale lethal effects to defeat multiple, rapidly maneuvering targets while reducing the cost of missile-on-missile engagement, deepening magazines, and providing complimentary depth of fire.

Power Projection

Also discussed previously, the Electromagnetic Rail Gun (EMRG) INP will provide multi-mission capability for long range, persistent, precision fire without unexploded ordnance issues, increased magazine capacity, and decreased cost. Projectiles will fire at a muzzle velocity of Mach 7.5 and reach targets 200+ nautical miles away in less than six minutes, impacting at a velocity exceeding Mach 5. In addition to Naval surface fire support, the EMRG will provide opportunities for Anti-Surface Warfare and self defense.

The Long Range Anti-Ship Missile (LRASM) is a joint Navy/DARPA demonstration program that will significantly advance anti-ship missile technology by demonstrating survivability while penetrating advanced air defense networks – and achieve robust lethality through precision targeting. A LRASM flight test is expected in FY 2012.

Affordable Platforms

Technologies intended to achieve Total Ownership Cost reduction while maintaining or improving system and platform performance are embedded throughout the S&T portfolio. ONR efforts such as the Navy Manufacturing Technology (ManTech) Program and the Enterprise and Platform Enablers FNC contribute to affordability in acquisition programs and throughout the lifecycle of systems and platforms. This includes using operations research, modeling and simulation, and computer sciences to reduce costs and improve the caliber of training and skill maintenance technologies. ManTech continues to focus on technologies to reduce costs of processing and fabrication for composites, electronics and metals, shipbuilding and repair technology, with technical engineering support with demonstrated savings for DDG 1000, CVN 21, Littoral Combat Ship, and VIRGINIA Class Submarines.

Future Power and Energy Systems

ONR continues to invest in advanced technologies to boost platform electrical power for improved warfighter capability and to increase energy efficiency to enhance platform endurance and reduce the warfighter's dependence on fossil fuels. Our S&T focus is on technologies and system architectures that increase both power density and energy efficiency. These efforts

directly support the Navy's energy strategy and the Secretary's energy goals of sailing a Green Fleet in 2016 and increasing DoN energy consumption from alternative sources.

In concert with DoD and Navy Task Force Energy's focus on energy security and reducing the amount of fossil fuel use, we continue to invest in the Naval Future Fuels effort, investigating the impact of new fuel formulations on Naval machinery and helping accelerate the Navy's adoption of alternative fuels. Additionally, ONR is supporting the Navy's partnership with the Department of Agriculture through collaborative research on biofuels. In FY 2010, congress added $18.5 million for Alternative Energy Research. We are using this funding to continue the evaluation of energy positive structures, advanced solar and wind technologies, ocean energy technologies, and system integration impacts of intermittent, renewable alternative energy sources on power grids. Finally, ONR continues to support research in fuel cells, methane hydrates, and other alternative sources of energy.

Modular Open System Architecture

Modular and open system architecture enables the Navy to affordably procure, modernize and integrate complex systems. By assembling similar components to provide a range of cost/capability trade-offs, modular system architecture can be used across all classes of ships. Open architecture enables affordable upgrades for introducing new technical advances to respond to new threats.

An example is the multi-function Electronic Warfare-Electronic Sensing (EW-ES) system ONR delivered to Program Executive Office – Integrated Warfare Systems (PEO-IWS). The system met operational requirements with scalable, open system architecture. The contract required the use of open interfaces and determined capability as a function of the number of receiver elements and channels. In addition, a third party provided components for some system elements. This allowed the PEO to not only use results of the S&T program for DDG 1000, but use underlying subsystems to develop the scaled back-fit for all ships in the Navy requiring EW-ES capability.

Similarly, the Affordable Common Radar Architecture program developed an architecture for all future radars in which the system is divided into frequency independent subsystems (radar control processor, human-machine interface, digital signal processor, digital beam-forming subsystems) which only need be developed once. They can then be used for all radars regardless of frequency and frequency dependent subsystems. The decomposition of radar into independent subsystems with open, well-defined interfaces enables Navy to procure the best components from any company and affordably upgrade only those elements which are necessary.

This experience led ONR to bring together a team of all major system integrators, along with key acquisition components, to develop Naval Radio Frequency (RF) modular system open architecture for the Integrated Topside INP. This will enable Navy to use modular construction to procure RF communications, moderate to low power radar, and electronic warfare capability across all ships with common RF hardware. This will reduce developmental acquisition, training and maintenance costs, and enable affordable upgrades due to open architecture.

This approach clearly involves acquisition challenges since various RF capabilities are currently funded by different Navy resource sponsors and acquired by different PEOs. In addition, the open subsystem construct may face Testing and Evaluation requirement challenges when only some subsystems are upgraded. I believe we can successfully address these challenges.

Information Dominance and Autonomy

The CNO has clearly signaled his intention of Navy taking the lead in information dominance. Since Naval forces must accomplish this without a growth in manpower, fundamental advances must be made in automated understanding of sensor and open source data, automated integration of highly diverse information, and the ability to automatically provide assessment and warning.

ONR S&T advances in automated image and video understanding in the 1990s became the foundation for many image and video industry standards today, as well as algorithms that have been used by the National Geospatial Intelligence Agency, other intelligence organizations, and industry. Funds were also invested in advancing the science of understanding, manipulating, and integrating so-called "soft" data such as human intelligence and open source data.

ONR also initiated development of strategies and algorithms to automate of the integration of highly disparate data sets, including sensor and non-sensor data in order to understand the relationships between individuals, objects, and events in the battlespace which provides insight into the capabilities of threats. This is a big job. Humans are called on to do it today, but there is insufficient manpower to manage today's information sets, much less what would result from the large sensor and information networks required to provide comprehensive, actionable battlespace intelligence.

Even after the integration of large volumes of data, the task of actually assessing the implication of the results across a dynamic battlespace is formidable. This is also an area which requires extensive manpower. To automate this requires major advances in machine reasoning and intelligence. In consequence ONR has sponsored a series of workshops including the Air Force, Army, DARPA, academia, industry, and other DoD participants to focus on critical issues and identify promising opportunities and high priority S&T investments. This research also forms the essential foundation that will enable large, diverse, mission-focused autonomous sensor and information networks for supporting rapid, accurate decision-making by commanders in the battlespace.

Marine Mammals and the Environment

ONR continues significant S&T investment dedicated to effective and responsible stewardship of the marine environment, including assessing the impact of national security activities on marine mammals. Navy is the worldwide leader in marine-mammal research, spending approximately $14 million annually to understand how marine mammals may be affected by sound. This figure represents a majority of funding for this research in the U.S., and nearly half spent worldwide, as Navy collaborates with universities, institutes, industry, conservation agencies, and independent researchers to better understand what combinations of ocean conditions and Naval activities could potentially impact marine mammals and the environment.

Understanding the Sea

Understanding the marine environment as a coupled system of atmosphere and ocean is critical for Naval operations including: Anti-Submarine Warfare, Mine Counter-Measures, and Naval Special Warfare. We work closely with Navy operational elements which make these forecasts. Our capabilities have steadily increased. Last year we added a novel hybrid coordinate ocean model. This year an important new variational assimilation approach to entering data into the models became operational with a significant increase in fidelity of the prediction. There remains much to learn about ocean processes, and our program has pursued a number of observational questions in the Western Pacific. A particularly important question is how the tides mix ocean water masses and create currents which affect the propagation of sound in the ocean and the abundance of marine ecosystems. Our goal is to capture the worldwide effect of tides in our prediction systems.

Highly capable research vessels are critical to the success of our basic and applied programs in ocean sciences. Since 1972, ONR has partnered with the National Science Foundation and other agencies in the University National Oceanographic Laboratory System (UNOLS) to allow joint scheduling and operations of a fleet of research ships used by academic oceanographers. The partnership continues with procurement of the next generation of Ocean Class research vessels. We are currently engaged in selecting from competitive proposals the two institutions that will receive these ships. There is keen interest in the selection and at the earliest possible time, Navy will let the committee know the result of this competitive process. Plans call for two ships to be built starting in FY 2011 and FY 2012, with lead ship delivery in FY 2014.

ONR Global

While we have tended to focus almost exclusively on the S&T process and programs, there is a worldwide dimension of S&T that we must address. This is because we have seen over 100 percent growth in global S&T investment over the last ten years.

In his book *Is America Falling off the Flat Earth?* Norm Augustine points out that among the top ten companies receiving U.S. patents in 2005, only four were actually U.S. companies. In recent rankings by the Organisation for Economic Co-operation and Development, the U.S. was 22nd in percent of GDP devoted to non-defense research. Up from 19 percent in 2004, China and India now account for 31 percent of the world's R&D workers. China has supplanted the U.S. as the world's leading high-tech exporter. In recent survey of 177 companies, 77 percent of new R&D sites planned over the next three years will be built in China and India, often with U.S. corporate financing. We must address, therefore, Navy awareness of—and access to—foreign S&T investments.

When Congress established the Naval Research Laboratory in 1916 and the Office of Naval Research in 1946 on the heels of World War I and World War II, the U.S. was arguably the world wide leader in S&T development and innovation. It is safe to say the U.S. monopoly no longer exists, making it imperative that we keep our finger on the pulse of S&T innovation in the international environment.

This is not new news; it is not even a new effort. ONR's London office, created to survey, assess, and report on European S&T activities was established coincidentally to the founding of ONR itself in 1946. ONR's office to similarly assess Asian S&T activities was opened in Tokyo in 1974. ONR subsequently opened a South America office in Santiago, Chile in 2004, a Southeast Asian office in Singapore in 2005, and most recently, a new office in Prague just last month. Our efforts are closely coordinated with the other services, the DoD Office of the Director, Defense Research and Engineering (DDR&E), and in full compliance with Section 211 of last year's National Defense Authorization Act.

The purpose of our effort is to search the globe for emerging scientific research and advanced technologies that enable ONR to address both current Fleet/Force needs, as well as requirements of future Naval missions and capabilities. We do this by working through ONR Global offices to establish new contacts and leverage relationships with international leaders in relevant research fields. This allows us to gain new perspectives and expertise, identify geographically significant trends and advances, and help forecast global trends and threats. It also enables us to recruit the world's best and brightest in research partnerships that benefit U.S. forces and allies.

ONR Global programs include the Science Advisor Program which communicates Fleet/Force capability needs to the Naval Research Enterprise (NRE) (consisting primarily of the Navy labs, warfare centers and affiliated universities) and facilitates the development of solutions that can transition back to the Fleet/Force. Program participants are typically engineers who coordinate and conduct Naval experimentation, develop prototype solutions, define transition options, and collaborate with Fleet/Force to define S&T investment needs to meet future Naval requirements.

To increase Naval awareness of global technology, our International Science Program provides scientists from academia, government and industry opportunities to engage leading international scientists and innovators. Our worldwide technical staff consists of twenty Associate Directors in ONR Global offices who establish relationships with international leaders in relevant fields, establish direct collaboration between ONR and NRL scientists and their foreign counterparts, and identify significant trends, accomplishments, and centers of excellence for Naval S&T strategic areas. This strengthens our ability to forecast both trends and threats in global S&T.

In FY 2008, International Science Program activities included our Visiting Scientist Program support for twenty visits to NRE facilities by scientists from 38 countries. Also in FY 2008, the Conference Support Program helped fund workshops at 117 conferences in 41 countries. And the Naval International Cooperative Opportunities Program supported 431 research projects in fifteen countries in which international scientists helped address Naval S&T challenges.

Conclusion

Thank you for the opportunity to discuss Naval S&T. The FY 2011 President's Budget request is about prevailing in today's threat environment and building a strong, flexible Naval force in the future. To achieve that goal, we continue moving toward greater integration of capabilities, more effective partnership between research and acquisition, and a clearer vision of how to achieve shared goals with DARPA, Army, Air Force, and other DoD research organizations.

S&T partnerships in 70 countries, 50 states, with 900 companies, 3,300 Principal Investigators, 3,000 grad students, and 1,000 academic and non-profit entities puts us in good stead to maintain our technological edge.

We continue to focus the majority of our investment on external performers – outside the Naval R&D system - in order to tap into the full spectrum of innovative thinking and discovery. Nevertheless, we need to nurture the world class skills and innovation that exist within our lab system, especially at the Naval Research Laboratory (NRL). Congressional authorization to move ONR into the Lab Demo personnel system provides welcome assistance in our ceaseless effort to attract world-class scientists to become part of our organization.

For all of these reasons, I believe the state of our S&T investments is sound, represents careful stewardship of taxpayer dollars, and will significantly enhance the safety and performance of our warfighters as they serve in defense of the United States, today and in the future. Thank you for your support.